Fact Sheet

National Aeronautics and
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Langley Research Center
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CALIPSO: A Global Perspective of Clouds and Aerosols from Space

From reports of increasing temperatures, thinning mountain glaciers and rising sea level, scientists know that Earth's climate is changing. But the processes behind these changes are not as clear. Two of the biggest uncertainties in understanding and predicting climate change are the effects of clouds and aerosols (airborne particles). The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite mission, currently under development, will help scientists answer significant questions about climatic processes by providing new information on these important atmospheric components.

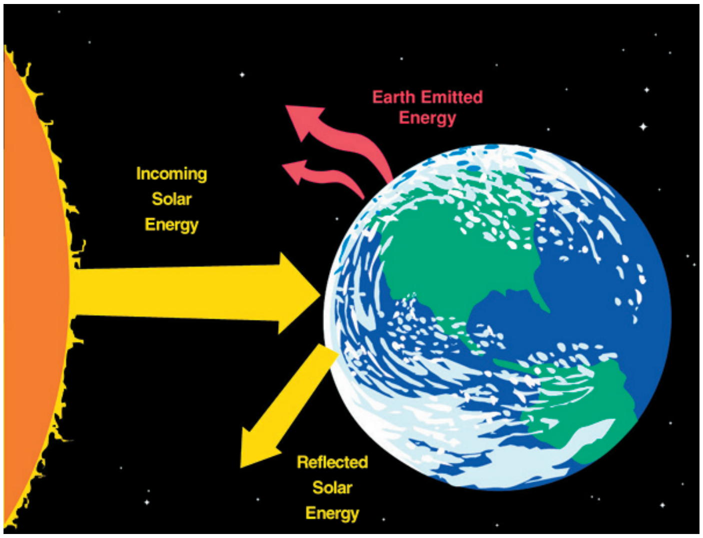
Scientists use computer programs called climate models to understand the behavior of and make predictions about climate. Climate models are mathematical representations of natural processes. While they are invaluable tools, more scientific studies are necessary to gain a greater confidence in their predictions. Clouds and aerosols are important variables in these models. Researchers need to learn more about how they help cool and warm the Earth, how they interact with each other and how human activities will change them and their effect on the climate in the future.

The CALIPSO satellite will give scientists a highly advanced research tool to study the Earth's atmosphere and will provide the international science community with a data set that is essential for a better understanding of the Earth's climate. With more confidence in climate model predictions, international and national leaders will be able to make more informed policy decisions about global climate change.

NASA's Langley Research Center in Hampton ,Va., leads and manages CALIPSO for the NASA Earth System Science Pathfinder (ESSP) program and collaborates with the French space agency Centre National d'Etudes Spatiales (CNES), Ball Aerospace and Technologies Corporation, Hampton University and the Institut Pierre Simon Laplace in France. CALIPSO, scheduled for launch in 2004, is designed to operate for three years.

The importance of clouds and aerosols to climate change

Everything, from an individual person to Earth as a whole, emits energy. Scientists refer to this energy as radiation. As Earth absorbs incoming sunlight, it warms up. The planet must emit some of this warmth into space or increase in temperature. Two components make up the Earth's outgoing energy: heat (or thermal radiation) that the Earth's surface and atmosphere emit; and sunlight (or solar radiation) that the land, ocean, clouds and aerosols reflect back to space. The balance between incoming sunlight and outgoing energy determines the planet's temperature and, ultimately, climate. Both natural and human-induced changes affect this balance, called the Earth's radiation budget.

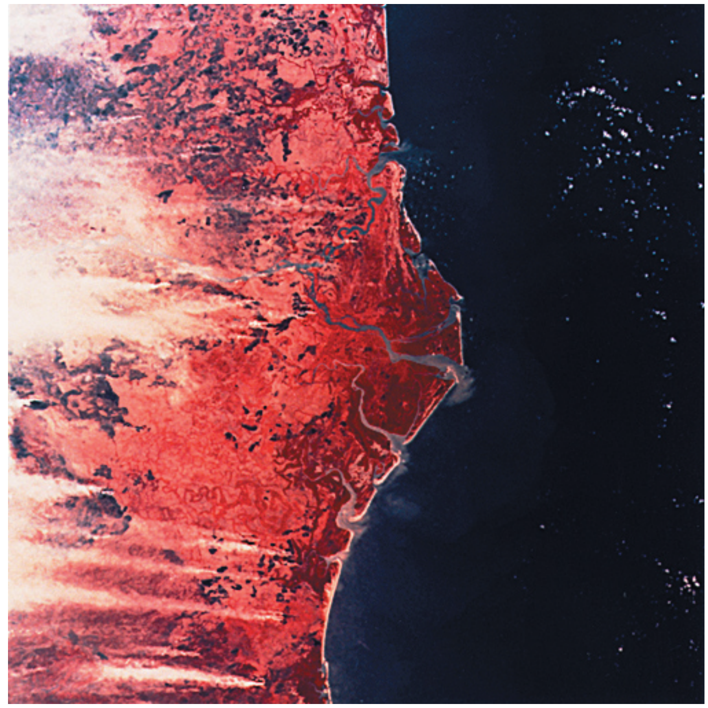


Earth's radiation budget is the balance between incoming and outgoing energy.

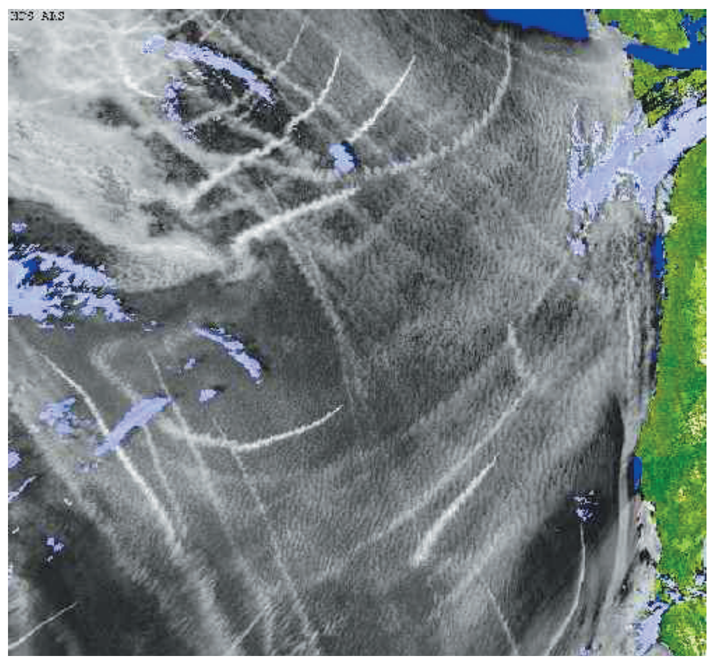
Clouds affect the radiation budget directly by reflecting sunlight into space (cooling the Earth) or absorbing sunlight and heat emitted by the Earth. When clouds absorb sunlight and heat, less energy escapes to space and the planet warms. To understand how clouds impact the energy budget, scientists need to know the composition of cloud particles, the altitude of clouds and the extent to which clouds at different altitudes overlap each other.

Both natural processes and human activities produce aerosols. They either reflect or absorb energy, depending on their size, chemical composition and altitude. The haze layer that is commonly seen in the summertime is one example of an aerosol that primarily reflects sunlight. Soot emitted by diesel engines is an example of an aerosol that absorbs sunlight. The reflection and absorption of energy by aerosols act in a direct way to change the balance between incoming and outgoing energy. These effects are called direct aerosol radiative forcing.

Aerosols also can affect the Earth's radiation budget indirectly by modifying the characteristics of clouds. Cloud particles almost always form around aerosols such as natural sea salt particles or human-made sulfate particles. The presence of additional aerosols can change the way clouds radiate energy and the length of time they stay intact. A good example is the way that exhaust particles emitted into the atmosphere by ships can increase the brightness of clouds along their course. These effects are called indirect aerosol radiative forcing.



Smoke plumes, such as those from grassland wildfires in southern Africa shown above, contain aerosols that directly affect the Earth's radiation budget.

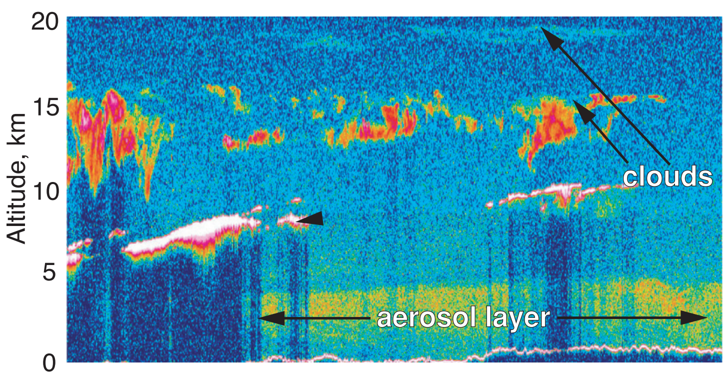


White cloud streaks over the Pacific Ocean off the coast of California stem from aerosols emitted into the atmosphere in exhaust from ship engines. Small water or cloud droplets form around these added aerosols, increasing the brightness of clouds over the ship tracks as compared to the surrounding clouds. This example illustrates the indirect effect of aerosols on the Earth's radiation budget.

A curtain of the atmosphere

Scientists have been observing clouds and aerosols globally from space for many years using passive imagers—sensors that measure the amount of energy leaving Earth. These sensors observe how clouds and aerosols vary with latitude and longitude but provide limited information on how they vary with altitude. To better determine how aerosols and clouds affect the Earth's radiation budget, scientists need to study how their distribution and properties vary throughout the atmosphere at different heights above the surface of the Earth.

The CALIPSO satellite will provide vertical, curtain-like images of the atmosphere on a global scale using a lidar. The lidar (light detection and ranging) technique is similar to radar in operation, but lidar uses short pulses of laser light instead of radio waves to probe the atmosphere. The lidar data from CALIPSO will allow scientists to determine precisely the altitudes of clouds and aerosol layers and the extent of layer overlap, to identify the composition of clouds and to estimate the abundance and sizes of aerosols.



The CALIPSO lidar will provide vertical, curtain-like images, such as the one above, of the atmosphere on a global scale.

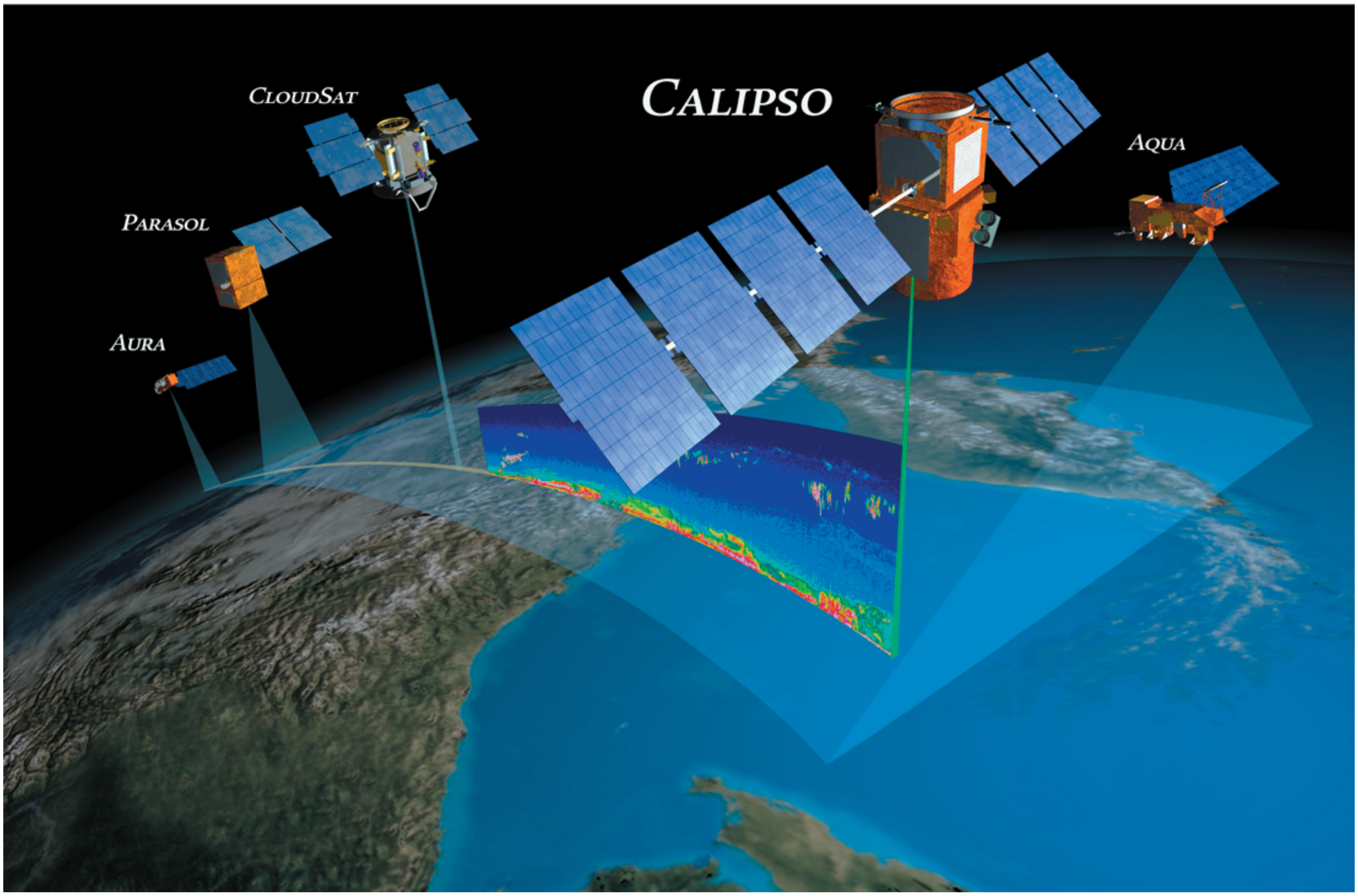
A three-channel imaging infrared radiometer provided by CNES will also be on the CALIPSO satellite. This instrument has a field of view of 64 kilometers by 64 kilometers (about 40 miles by 40 miles) and measures outgoing heat emitted toward space from the atmosphere and surface of the Earth. Its design will allow scientists to estimate the size of ice cloud crystals and the amount of heat these clouds absorb and emit.

The CALIPSO satellite will also carry a high-resolution digital camera with a field of view of 60 kilometers by 60 kilometers (about 37 miles by 37 miles). The camera provides a large-scale view of the atmosphere surrounding the thin column of air probed by the lidar. Images from the camera will improve the ability of scientists to interpret the lidar observations. For example, the images collected by the camera will allow scientists to determine if the lidar measurements are from a small, isolated cloud or a cloud that is part of a larger air mass.

The future of CALIPSO

CALIPSO is scheduled to fly in formation with four other satellites that will collect a wide variety of coincident measurements. Each satellite in the formation offers unique information on clouds and aerosols. Combining their data will provide greater insight than could be gained from a single satellite. The Earth Observing System (EOS) Aqua satellite, which is focused on understanding the Earth's water or hydrological cycle, will collect data on the geographical distribution of clouds and aerosols, atmospheric temperature, moisture content and the radiation balance at the top of the atmosphere. CloudSat, a sister ESSP satellite experiment, will use a radar to provide vertical profiles of thick clouds that lidar cannot penetrate. The EOS Aura satellite will monitor atmospheric chemistry and dynamics and will provide information on the geographic distribution of absorbing aerosols. Finally, the PARASOL (Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a Lidar) satellite, being developed by CNES, will provide unique information on aerosols and clouds using a multi-channel, wide field-of-view, polarization-sensitive camera.

Upon successful completion of the CALIPSO mission, the collected data will allow scientists to better understand aerosols and clouds and, ultimately, improve climate models. CALIPSO observations will improve global estimates of how aerosols affect the Earth's radiation budget and of the flow of heat between the Earth's surface and the top of the atmosphere. Using CALIPSO, scientists will have a new way to determine how the climate, aerosols and clouds interact.



CALIPSO will fly in formation with the Aura, PARASOL, CloudSat and Aqua satellites

For more CALIPSO information, please contact:

NASA Langley Research Center
Office of Public Affairs
Mail Stop 115
Hampton, VA 23681-2199
757-864-6121
http://www.larc.nasa.gov/

Also, see the CALIPSO Home Page:
http://www-calipso.larc.nasa.gov

The Atmospheric Sciences Home Page:
http://asd-www.larc.nasa.gov

Or the ESSP Home Page for additional information:
http://essp.gsfc.nasa.gov